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AN ADDRESS

BEFORE THE

Alumni of Yale College,

AT THE

COMMENCEMENT ANNIVERSARY, AUGUST, 1856.

By JAMES D. DANA,

SILLIMAN PROFESSOR OF NATURAL HISTORY.

PUBLISHED AT REQUEST OF THE ALUMNI.

NEW HAVEN:
PUBLISHED BY S. BABCOCK.
1856.

ADDRESS.

GENTLEMEN OF THE ALUMNI:—

THESE annual pilgrimages over the breadth of the land to the groves of our Alma Mater have deep meaning. No duties of penance, nor hopes of ghostly reward, turn hither your steps. Thoughts of the past possess the soul, rather than care for the future: the familiar faces, the old red buildings, the sheltering trees, and the scenes of mirth, of friendship, or of serious effort, here enacted. Still more stirring is the consciousness with each of us, that amid these groves the mind first rose into manhood, and collected strength for the conflicts of life:—the mind's birth-place,—should not the spot be honored?

Besides these reflections, there is the pride, the just pride, that the nation has within these halls one of its best and most abundant sources of wisdom and virtue;—wisdom that takes hold on heavenly things while striking deep into the things of earth; virtue, that has its sure foundation in universal right and universal freedom.

It is natural on meeting friends, long absent, to seek out the marks of progress, to recount together the joys and trials along the way of life,—the new fields the affections have explored, the new conquests in the career of study or duty, or, perchance, the ineffectual labors and blighted hopes that have demanded still higher conquests. It is natural to ask, whether this or that one has fulfilled the promises of youth; whether he has become wiser with his years, and has expanded in spirit as well as intellect with every new movement of mankind; or, whether the dead languages still lie dead in his soul, himself a thing of the past rather than of the living world. With the varied responses to these and other thoughts, we find some occasion for sadness; much for delight and

gratulation; and, however it be, there is always happiness and invigorating influence from interchanged words and sympathies.

But with many, the inquiries will not stop here. How is it, they add, with our Alma Mater? Does the honored institution show signs of growth in these growing times? or is she linked with the past rather than the future, resisting progress as if it led only toward evil? All life in nature involves change; and there is no hope for humanity except in the same universal principle: but, with perverted view, is change here looked upon as only a step toward destruction?

Sounds have gone forth from these groves, which have told that Yale is awake to all that stirs the world around, declaring that she recognizes in man, yea, in all men, the divine image, and seeks to promote the full expression of that image as the highest exaltation of humanity.

Again, in her literary course, there is progress, as regards the range of studies, the character of examinations, the style of thought, and grade of scholarship.

There is another point of interest connected with the world's progress. The researches of the past one hundred years have opened new fields of thought, new revelations of profound truths direct from God's works, and the world, through the energies thus derived, is pressing onward with accelerating speed. Through the darkness, black as night, that seemed to be a bound to past time but 6,000 years off, geology has opened a vista in which she has traced the Divine Word, in glorious thoughts, all along the Ages. How does the College treat these new notions, and science generally? as modern inventions of Satan? Does she turn her back, and cry "*Procul?*" Does she adopt the half-stereotyped phrase, "The infidelity of modern science," and shed bitter tears because she can not help it? Does she regard the Arts as only so many ministers to luxury and debasement?

There still stands among us one whose eloquent words have for fifty years made the truth resound through these consecrated halls, and whose far-reaching tones have been reëchoed from every portion of the land. And thus Yale College has ever been in the van, never afraid of the progress of truth.

Yet there are many who still look with distrustful eyes on science: (under this term science you will understand me, here and elsewhere, as referring to the science of nature.) They seem to see a monster swelling up before them which they can not define,

and hope may yet fade away as a dissolving mist. They deprecate its influence upon our literary institutions, and the great interests of mankind. The word *nature*, though another expression for God's works, appears to them to smack of Atheism, and all education that touches on the useful, to be tainted with the mammon of unrighteousness. They overlook the fact that almost all works on science in our language, endeavor to uphold the sacred Word, those opposing it being exceedingly few; and that infidelity proceeds not from science, but from that one fatal and prolific source, man's depravity.

Notwithstanding all the protestations that may come from such unbelievers in God's revelations through nature and his plan for human progress, Yale College is ready to encourage science on a scale commensurate with its importance. For some years, the scheme has been recognized in her catalogue, under the title of "The Department of Philosophy and the Arts;" and now it is proposed to realize this scheme, at least in some of its branches. She would not, however, commit the folly of sacrificing herself in deference to philosophy and the arts. Yale will stand as she is, abating not her terms of admission, nor her grade of scholarship, and aiming still to give that thorough classical training, and that broad foundation of principles in the departments of nature, mind, and moral truth, which tend to the complete cultivation of the man. The system she has hitherto followed, though admitting of some improvement, affords in fact the true basis for the student that would ascend the highest paths, whether of literature or science. But she also recognizes that God has purposes of love in opening to man these other avenues of knowledge, and she would offer a place along side of the Academic Department for "Philosophy and the Arts," in their fullest display, where mutual benefits may be derived, and the ripening man find development, whatever his tastes or pursuits.

My object at this time will be mainly to give some account of the university feature in education which it is proposed to connect with the existing college system. But the claims of science are not so generally admitted or understood as to need no advocate; and I ask your attention first to some thoughts on this subject.

When man, at the word of his Maker, stood up to receive his birthright, God pronounced a benediction, and gave him this

commission: "REPLENISH THE EARTH: SUBDUE IT: AND HAVE DOMINION OVER EVERY LIVING THING."

"SUBDUE AND HAVE DOMINION." These were the first recorded words that fell on the human ear; and Heaven's blessing was in them.

Man has long obeyed the mandate in bridling the brute races. But there is a deeper meaning which he has been slow to discover. In utterances, not to be mistaken, they declare to him:—"All the powers of nature, both animate and inanimate, are your heritage. The air, the waters, the earth, the light and the fierce lightning, as well as the productions of sea and land,—all are at your bid. Subdue; and they shall be your obedient aid, ministering to your necessities, your joys, and your highest progress." Even as the Being above us holds the universe in his hand, so man was to show forth the divine nature within him, by bringing under his ken and power, the world in which he was placed, and wielding its forces at his pleasure.

Such a Divine command was a lofty exhibition of the majesty of man. The earth, in its progressive preparation for him, had been receiving one perfection and adornment after another. The stars and earth had been bound together in system, and messages of light passed in mutual recognition of their one Author. The foundations of the earth had been laid in enactments inscribed on every crystal and grain of sand or drop of water. The kingdoms of life had appeared as still nobler expressions of his wisdom. And God, from the height of his glory, had pronounced all his work GOOD. Thus the earth had been the place of Divine regard and favor: the Infinite Author had written it over with declarations of himself, and filled it with messages of his love.

But this volume of eternal wisdom remained yet a sealed book. What an unspeakable exaltation of Man, that to him were given the keys! the power to open, and read, and apprehend, although its words were in the hand-writing of the Infinite Author! to appreciate beauty which to Him was beauty! to decipher and understand the profound system of the universe! to venture on almost boundless excursions through space, and as profound searchings into the past! to appropriate the treasures of life, and turn the currents of nature's forces into his own channels! to rise from the dust of earth to the throne of power, and say to nature, "GO:"—and it goeth! Surely there was a declaration of man's dignity we can not yet apprehend in those words, "SUBDUE IT."

But what is this subduing of the earth? How is nature brought under subjection? Man's highest glory consists in obedience to the Eternal Will; and in this case, is he actually taking the reins into his own hands? Far from it. He is but yielding submission. He is learning that will, and placing himself, as Lord Bacon has said, in direct subserviency to divine laws. When he sets his sails, and drives over the waves before the blast, feeling the pride of power in that the gale has been broken into a willing steed, he still looks up reverently, and acknowledges that God in nature has been his teacher, and is his strength. When he strikes the rock, and out flows the brilliant metal, he admits that it is in obedience to a higher will than his own, and a reward of careful searching for truth, in complete subjection to that will. When he yokes together a plate of copper and zinc, and urges them to action by a cup of acid—and then despatches burdens of thought on errands of thousands of miles, man may indeed claim that he has nature at his bid, subdued, a willing messenger; and yet it is so, because man himself acts in perfect obedience to law. He may well feel exalted: but his exaltation proceeds from the fact that he has drawn from a higher source of strength than himself, and a mind not morally perverted, will give the glory where it is due.

These are the rewards of an humble and teachable spirit, kneeling at the shrine of nature: and if there is indeed that forgetfulness of self, and unalloyed love of truth which alone can ensure the highest success in research, this shrine will be viewed as only the portal to a holier temple, where God reigns in his purity and love.

The command, "subdue, and have dominion," is, then, both a mark of man's power, and of God's power. It requires man to study his Maker's works, that he may adapt himself to his laws, and use them to his advantage;—to become wise, that he may be strong;—to elevate and ennoble mind, that matter may take its true place of subjection. It involves not merely a study of nature in the ordinary sense of those words, but also a study of man himself, and the utmost exaltation of the moral and mental qualities; for man is a part of nature; and moreover, to understand the teachings of Infinite Wisdom, the largest expansion of intellect, and loftiest elevation of soul are requisite.

Leaving out of view the moral aspect of the question, let us look for a moment at the history of man's obedience to this injunction.

Solomon says, that in his day, "there was nothing new under the sun." What is, is what has been, and what shall be. The

sentiment was not prompted by any modern scientific spirit,—impatience of so little progress; for it was immediately connected with sighings for the good *old* times. Much the same spirit is often shown in these days, and elaborate addresses are sometimes written to prove that after all our boasted progress, Egypt and Greece were the actual sources of existing knowledge. They point to the massy stones of the pyramids; the sublime temples and palaces of the old empires; the occasional utensils of half-transparent glass, and implements of bronze or iron found among their buried ruins; the fine fabrics and costly Tyrian dye;—they descant upon the wonderful perfection attained in the fine arts, in poetry and rhetoric, and the profound thought of the ancient philosophers:—and then are almost ready to echo, "There is nothing new under the sun." What is, is what has been. *Those good old times!*

But what had those old philosophers, or the whole ancient world done toward bringing nature under subjection, in obedience to the command, "subdue it?"

They had, it is true, built magnificent temples. But the taste of the architect, and that of the statuary or poet, is simply an emanation from the divine breath within man, and is cultivated by contemplation, and only surface contact with nature.

They piled up Cyclopean rocks into walls and pyramids. But the use of the lever and pulley comes also from the workings of mind, and but shallow views of the world. And adding man to man till thousands work together as in one harness, has been a common feat of despots from the time of the Pharaohs onward.

They educed profound systems of philosophy, showing a depth of thought since unsurpassed. But these again were the results of cogitating mind, acting in its own might,—glancing, it may be, at the landscape and the stars in admiration, but centering on man and mind; and often proving to be as erroneous as profound.

They cultivated the intellect, and made progress in political knowledge. But in their attempts to control nature, they brought to bear little beyond *mere physical force.*

Although ancient wisdom treats of air, earth, fire, and water, not one of these so-called elements was, in any proper sense, brought under subjection.

The *Air:*—Was it subdued, when the old Roman still preferred his banks of oars, and on the land, the wind was trained only to turn a windmill, carry off chaff, or work in a bellows?

Was the *Earth* subdued, when instead of being forced to pour

out in streams its wealth of various ores, but half a dozen metals were known? and instead of being explored and found to be marshalled for man's command, under sixty or more elements, each with its laws of combination and all bound to serve the arts, the wisest minds saw only a mess of earth, something to tread upon, and grow grain and grass?

Was *Fire* subdued, when almost its only uses were to warm, and cook, and to bake clay, and few of its other powers were known, besides those of destruction? or *Light*, when not even its component colors were recognized, and it served simply as a means of sight, in which man shared its use with brutes?

Was *Water* subdued, when it was left to run wild along the water-courses, and its ocean-waves were a terror to all the sailors of the age? when steam was only the ephemeral vapor of a boiling kettle, yet unknown in its might, and unharnessed? when the clouds sent their shafts where they willed? when the constituents of water,—the life-element *oxygen*, and the inflammable *hydrogen*, had not yet yielded themselves to man as his vassals?

Hardly the initial step had been taken, through the thousands of years of the earth's existence, to acquire that control of nature which mind should have, and God had ordered. The sciences of observation and experiment had not emerged from the mists of empiricism and superstition. There were few ascertained principles beyond those that flow from mathematical law, or from cogitations of mind after surface surveys of the world.

No wonder that nature unsubdued should have proved herself a tyrant. She *is* powerful. Vast might is embodied in her forces, that may well strike terror into the uninstructed: and man has shown his greatness in that he has at last dared to claim obedience. The air, earth, water, fire, had become filled with fancied fiends, which any priest or priestess could evoke; and even the harmless moon, or two approaching or receding planets, or the accidental flight of a thoughtless bird, caused fearful forebodings; and a long-tailed comet made the whole world to shake with terror.

Christianity, although radiant with hope, could not wholly break the spell. The Christian's trust, Heaven's best gift to man, makes the soul calm and strong mid dangers, real or unreal; yet it leaves the sources of terror in nature untouched, to be assailed by that power which comes from knowledge.

Man thus suffered for his disobedience. He was the slave,—nature, the feared master, to many even the evil demon himself.

Is this now true of nature? We know that to a large extent, nature is yet unsearched and unsubdued. Still, vast progress has been made toward gaining control of her ten thousand agencies.

In gathering this knowledge, we have not sought for it among the faded monuments and rolls of the *ancients*, as we call the inhabitants of the earth's childhood; but have looked to records of vaster antiquity—the writings of the infinite God in creation, which are now as fresh with beauty and wisdom as when His finger first mapped out the heavens, or traced the flowers and crystals of the earth. This is the fountain whence we have drawn: and what is the result?

How is it with *water* in these last times? Instead of wasting its powers in gambols down valleys, or in sluggish quiet about "sleepy hollows," it is trained to toil. With as much glee as it ever displayed running and leaping in its free channel, a single stream now turns over a million of spindles in this New England.

Changed to steam, there is terror in its strength even now. Yet the laws of steam, of its production, condensation, and elasticity, have been so carefully studied, and also the strength and other qualities of the metal used to confine it, as well as the nature and effects of fuel, that if we are careful not to defy established principles, steam is our most willing worker,—turning saw-mills, printing-presses, cotton-gins,—speeding over our roads with indefinite trains of carriages and freight,—bearing away floating mansions, against wind and tide, across the oceans,—cooking, heating, searching out dyes from coarse logwood, and the like,—and applying itself to useful purposes, one way or another, in almost all the arts. Again, if we will it, and follow nature's laws, water gives up its oxygen and hydrogen, and thus the chemist secures the means of burning even the diamond; the aëronaut makes wings for his adventurous flight, and the light-house derives the famous Drummond light for its work of mercy. And when he chooses, man may unite the oxygen and hydrogen again, and re-form the original water.

Light is no longer a mere colorless medium of sight. We may evoke from it any color we please, either for use or pleasure. We may also take its chemical rays from the rest, or its light rays, or its heat rays, and employ them separately or together; for we have found out where its strength lies in these particulars, so that, at will, light may pass from our manipulations, shorn of its heating power, or of its power of promoting growth or chemical change. Aye, the subtle agent will now use its pencil in taking sketches

from nature, or portraits, if we desire it:—and the work is well done.

The ancient wise men, discoursing on the power which holds matter together, sometimes attributed to the particles convenient hooks for clinging to one another. Little was it dreamed that the force of combination in matter,—now called attraction,—included the lightning among its effects, and would be made to run errands, and do hard work for man. Electricity, galvanism, magnetism, are modern names for some of the different moods under which this agent appears; and none of nature's powers now do better service. It is kept on constant run with messages over the continents, scaling mountains, or traversing seas, with equal facility. It does our gilding and silver-plating. Give it an engraved plate as a copy, and it will make a hundred such in a short time. If taken into employ, it will, in case of fire, set all the bells of a city ringing at once; or it will strike a common beat for all the clocks of a country; or be the astronomer's best and surest aid in observing phases in the heavens, or measuring longitude on the earth. All this and more it accomplishes for us, or can if we wish, besides opening to our inquiring eyes the profound philosophy which God has inscribed in his works.

Nature is no longer full of gloom and terror. Her fancied fiends have turned out friends. Although God still holds supreme control, and often makes man remember whence his strength, yet every agent, however mighty in itself, is becoming a gentle and ready assistant, both in our work and play,—in the material progress of nations, as well as their moral and intellectual advancement. Art is thence receiving daily contributions, and already realizes that no knowledge for service, compares with that which comes direct from nature.

It is apparent also, that only the most profound and scrutinizing research, with an earnest and docile spirit, can discover the unseen wealth of nature; for the great truths which have proved so fertile in results, have been sought out by those only who have given themselves, with all their might, to the deep study of God's laws in his works.

Thus it is that fact has been added to fact, until facts have become principles, and principles have expanded until they finally blossomed and spread their fragrance and fruit over the land, while the many receiving the blessing were ignorant whence it came.

A farther reference to the history of science will exhibit more

clearly the dependence of the arts on scientific progress; and I must ask your indulgence, if I refer to familiar facts for the sake of illustration.

Some knowledge of electricity, that is, the power evolved on rubbing glass, amber, resin, or sealing-wax, and other substances, was afloat in the ancient world. But until near fifty-six hundred years had passed, there was not an established principle even in prospect. A little more than a century since, the power was at last collected in quantities and imprisoned by means of the Leyden jar. Its shocks and sparks and other feats were among the wonders of science; but art had yet reaped nothing.

At this time, Franklin commenced experimenting on electricity; for the bruit of the Leyden jar had crossed the waters. He at once thought he saw miniature lightning in the sparks; and soon after, by means of his kite, as you well know, proved his induction right. After thus tapping the clouds for his experiments, he asked, Why not disarm the clouds, by planting perpetual conductors about our dwellings? It was done: and electricity shed its first fruits over the world.

Near forty years later, ten before the last century closed, a frog's leg freshly prepared for cooking, lying on a table in Galvani's house, on which was a charged electric battery, was observed to twitch convulsively when touched by a knife. Galvani took the hint, and after a series of experiments, thought he saw evidence of a new power in animal life, passing between the nerves and muscles. Volta soon disputed Galvani's theory of animal electricity, and set to work examining the conditions of the leg, its metallic connections and other circumstances. In pursuit of the simple truth, thinking that perhaps mere moisture might be an agent in the phenomenon, he placed a plate of silver on the back of a living frog, and another of zinc below, and on pressing gently, and bringing the plates into contact at one edge, the frog twitched all over, though no nerves were exposed. He next put the same metals together with only a moist piece of cloth or paper between, and, on connecting the two metals by a wire, observed at the moment of connection, an effect on an electrometer precisely like that caused by electricity. All that he required to produce the result, was a coin or disc of silver, (or copper,) a similar disk of zinc, and between the two, a disc of cloth, nearly as large, wet with salt water. He then added to the little triplet of silver, wet cloth and zinc, another triplet of silver, wet cloth and zinc, and another, and so on,

making a pile. With three or four such triplets in the pile, on touching one extremity of the series with a moistened finger of one hand, and the other extremity with a finger of the other hand, he felt a slight shock in his fingers, apparently of the same nature with that in the frog's leg: and as the pile increased in height, the shock increased; and moreover, he finally obtained a spark like that from the Leyden jar. It was light to the mind as well as eye. The movement of the frog was explained, while something very like electricity was evolved under extraordinary circumstances.

In this little pile—the voltaic pile, as it has been called—the first step was taken on a road leading deep into nature's arcana. Yet neither the world nor Volta then knew its future. Many, no doubt, were the contemptuous inquiries, "*cui bono?*" following a shrug at the shock felt at the finger-joints and elbows.

Others immediately after took up the line of investigation. The pile was changed into a trough containing a series of couplets of zinc and copper, alternating with narrow chambers filled with acid, in the order, zinc, moisture, copper, as used by Volta; and a brilliant series of developments commenced. The way had been prepared by the recent growth of the science of chemistry, which had made rapid progress since the discovery of oxygen, by Priestley, in 1774.

In experimenting with the battery, on bringing wires from the two ends into contact, intense heat as well as light was observed, melting or burning the wires:—*one new principle*, that this force will produce great heat.

Upon dipping the ends of these wires into a glass of water, bubbles of gas escaped from each, proved afterward to be the elements of water: hence, *another new principle*, that galvanism has the power of sundering the elements of a compound, or decomposing it. It was strange to most eyes, and nothing more; and to the question what is the use, there was little yet to show. Sir Humphrey Davy, pursuing this thought, obtained from potash, a metal afterward called *potassium*, that would float and burn on water; and from soda, another, *sodium*, almost as inflammable. But the quantities produced were very small, and there was nothing for the arts. It was observed, also, that on using in the battery the salt called sulphate of copper or blue vitriol, the metallic copper of the salt was abundantly deposited on the zinc, illustrating farther, this power in galvanism of decomposing compounds; but the fact was unproductive, except of inconvenience.

As years passed on and investigation continued, it was discovered that galvanism could make magnets out of any metal; that magnets could produce the effects of galvanism, give shocks and sparks, and decompose water; that electricity also could be made to decompose water, like galvanism. In fact, it became apparent that these three agencies were akin, and probably one in origin. But there was still heard the sneering "*cui bono*," which saw no good in studying truth for its own sake, and had no measure of its value but the moneyed return.

It is the glory of the arrangements in the physical world, that beauty and utility mostly go together. The former, is first and always reached, and is the boon to tempt the mind onward in research. By and by the practical comes forth in abundance, and then mind has its double reward. We have faith that the slow-growing tree, which for years is expanding in leafy beauty, will yet afford a rich return: at last the buds appear; then the flowers open out in their splendor; and finally, both beauty and utility oftimes reach their climax together, in the ripened fruit, one heightening the effect of the other. Such should be our faith in the study of nature; for however dry the work of him who delves, nature has treasures in profusion to reward the labor.

About forty-five years after the twitching of Galvani's frog, the time of blossom and fruit came; and such a succession of benefits from nature never before descended on the globe in any one ten years.

In 1837, Professor Morse, one of our own number, was already setting up his telegraph, bringing into its construction the well-known principles of the electro-magnet and galvanic battery; and now telegraphic threads, along which thought travels with almost the speed of light, are enveloping a large part of the globe.

About the same time, the fact of the deposition of copper from a copper salt, became a productive principle. It was found that copper could thus be deposited over an engraved plate, and a perfect copy made of every line or dot. The happy thought soon developed into a new art—that of electrotyping. A single engraved plate could thus be indefinitely multiplied, and the original retained unhurt.

But the art was not confined to this purpose alone. Books, till then, had been stereotyped by making a plaster cast of a surface of a page set in type, and then taking casts of lead in the plaster. Now they take the first cast in wax, cover its surface with powdered

black lead, and carry it to the galvanic battery. Thence, it soon comes out, a cast of the page in copper, far more perfect than the old stereotypes, more expeditiously made, and more durable. The Bible House in New York, is now full of electrotypes; they scarcely print from any thing else. The fine wood-engravings, so profusely adorning some of the Tract House publications, and many of the illustrated works and magazines of the day, are printed from electrotypes alone. Thus the great art of book-making, and therefore the whole world of mind, and all that is sacred as well as secular, are reaping results from a science that germinated first in that queer little pile of Volta, which in the opinion of the economists of its time, was of no earthly use to any body.

But if type and engraved plates, and wood-cuts may be copied, why not copy other things in the same way? In fact, the process is used for the reproduction of works of art; and thus immense establishments now manufacture medals, bronze statues or statuettes, and bas-reliefs, in a style of great beauty and perfection, and at moderate cost.

Shortly after the first electrotypes were made, it was observed that the deposition of silver or gold, through galvanism, on copper, and some other metals, served as a convenient mode of plating; and to-day nearly all the silvering and gilding on metal required in the arts, is done by electro-plating. Minutes now stand for the hours of the old regime.

Some years ago, it was thought that if electro-magnetism could move the machinery of the telegraph, and mark down or print off the passing thought on paper, it would also register the beats of a pendulum. Or, if so willed, it would repeat the beats of any *one* clock all over the land, wherever it was sent along wires for the purpose. And already, in some cities, they are beginning to distribute and sell *time* as they do *gas*, one single time piece *timing* the town, as one gas establishment *lights* it. At Marseilles, they are, this very year, putting time-pieces, thus fed, into all the lamps of the lamp-posts along the public streets, which may be read at night as well as by day.

To our own country belongs the honor of this application of science. At this moment, the astronomical clock at Cambridge beats time in all the railroad depots at Boston; and but a few weeks since, the Dudley Observatory at Albany, proposed to supply the city of New York with time, the observatory drawing upon the stars for its supply.

The astronomer has other higher uses for the subtle agent, for he makes it his private secretary, requiring it to register on paper, the time of his observations, and help map off the heavens. If a strip of paper have a straight, uniform motion, and as it moves on, just touches the point of a stationary pen or pencil, a mark is made on the paper, which obviously would be twice as long for two seconds as for one; and so on. If then, for every second, a mark an inch long were made, every inch would represent a second. Thus seconds may actually be converted into feet, and time may be measured by the yard-stick; or with a delicate scale, a second may be subdivided into tenths and hundredths of a second. This simple and ingenious idea, the astronomer applies to his purposes by means of a clock and a telegraphic apparatus; and now instead of counting the ticks of his clock, he touches a key at the moment of a transit, or other event in the heavens; this makes a check on the paper, and so marks the precise time, even to a minute fraction of a second. The observations thus made, are not only vastly more accurate than those on the old plan, but may follow one another with incredible rapidity; so that in one night, more work can be done than before in a month.

This invention, the work mainly of American mind, by which electro-magnetism has become the astronomer's most faithful assistant, is now introduced into some of the best observatories of Europe.

The difference of longitude between points over this continent, and between Greenwich and the observatories of Europe, has been ascertained by the same means, and with like accuracy. This, too, was an American suggestion. And when the telegraph wires now in progress are laid across the Atlantic, the difference of longitude between Washington and Greenwich will be as exactly known. Who imagined fifty years since, that the galvanic fluid would help us measure distance on the earth, and that the geographer would have cause to bless the lightning as well as stars!

With equal facility, this agent has been adapted, as I have said, to the fire alarm bells of a city. Where employed, one man may strike every bell in the city, though miles apart, at the same instant; and a slight movement of the finger is all the power he exerts; at one tap, the ringing begins, and it continues without further effort. At the same time, too, instantaneous notice of the place of the fire may be sent to every engine house.

The same agent is playing errand-boy in hotels, displacing the

brazen-tongued messengers that were regularly kept on file in the office.

All these,—and many more results might be added,—are developments from that unseen force which Galvani and Volta were the first to recognize, after the world was almost *fifty-eight hundred years old!*

In this review of the useful in science, I have left wholly unnoticed the beautiful results of photography, and other uncounted gifts of chemistry to the arts, and the contributions also from the departments of light, heat, and natural history, that are variously enriching the world. But I must stop here, my illustrations, for want of time. I think I have abundantly shown that this modern age far transcends the ancient world, through its obedience to the injunction, *Subdue, and have dominion;* that man has thereby grown in wisdom and power; that progress in science is hence demanded as our bounden duty. Every principle of our being prompts to its study: our love of the beauty and grandeur of truth; our eagerness for startling developments or novelties; our ambition as a nation to rise in wealth and honor; our very avarice: all urge us to search out nature's laws. And those whom I have the honor to address will also appreciate the still nobler sentiment, that God is here making displays of his glory, and giving lessons to man on a subject loftier than art, even his own transcendent wisdom in the great plan of creation.

Science is an unfailing source of good. And as the laws of God are universal, even more so than air and water, so every new development is destined to bestow some universal blessing on mankind. Complain not, if the reward be long delayed. Man has not the prescience that entitles him to declare any truth in nature useless, however barren to present view. The tree and fruit come from the germ; and no one will denounce the seed because the blossoms are not yet visible.

If evil appears mixed with the good, let us remember that it is so mixed in the heart of man, and this is its only source. The face of nature is as pure as the atmosphere of heaven, and if, in our looking, we see aught that is bad, it is a graft from tainted humanity.

The working of self-reliant mind, not the study of nature, has been the prolific source of error in philosophy and religion. Proud man, trusting to himself, looking within for knowledge, and hoping by simple, unaided thought, to fathom the depths of nature as well

as mind, has reached one error after another; and thus pantheism and other false systems of belief have been engendered.

Mind, through its intuitive principles, and its capacity of cultivation and development, is made for the contemplation of God's works and word; and it is our exalted privilege thus to be pupils,—pupils of the infinite God, himself our teacher and our study. For his works and his word are two revelations of himself which he has adapted to our finite natures:—the *first*, a manifestation of God the Creator, displaying his wisdom, power and beneficence; the *second*, a manifestation of God the Supreme Ruler, exhibiting his holiness and love, and having its consummation in the advent of Christ, who is "God with us," the light and life of the soul. In apprehending spiritual things, we thus are not left to ourselves; we even have besides this revelation, the aid of the ever-present Divine Spirit. And with regard to God's works, we search our own minds in vain for truth: but looking to the works themselves, we find wisdom welling up even at our feet. This wisdom is that we call *science*, the science of nature.

It is painful to witness the dread of this science that is so often displayed, when, as I have said, the real origin of mischief, as far as it is intellectual, is in that old method of philosophy which makes systems of nature out of baseless cogitations.

Geology, of all the sciences, has been most denounced for alleged infidelity: and yet it is the very one among them, that has come most valiantly and successfully to the combat against error. It is proving, what none other could prove, that God's hand, omnipotent and bearing a profusion of bounties, has again and again been outstretched over the earth; that no senseless development principle evolved the beasts of the field out of monads, and men out of monkeys, but that all can alike claim parentage in the Infinite Author; that the earth has been ordered through a long history, in its plant and animal life, its accumulating rocks and minerals, its rising mountains, shaping continents, and deepening seas, with reference to man, his whole intellectual and religious development. Tenfold power beyond that from any other source, is thus given to the evidence of a moral and spiritual purpose in creation; and this established, we have the highest proof nature can afford of a personal God over creation.

Science should not be feared. Her progress is upward as well as onward, to clearer and clearer visions of infinite beneficence. Her platform is not a shifting one. She stands on truth, looking

wistfully to brighter realms above. And if, while in eager gaze, her conceptions respecting regions yet unreached are vague, or in any way erroneous, each step forward is to a higher level, where she may resolve what before was dimly seen. Thus she rises from truth to loftier truth, dispelling the error that may be mingled with her deductions. Press her forward, then, with all your might; for in her progress, the finite is taking proffered strength from the Infinite. It is cowardly, it is wrong to God and ourselves, to doubt.

The Atheism which has long possessed much of the intellectual philosophy of man, may and will strive to use the developments of science for its ends; and in this evil world, a blighting influence from such a source will long be felt. But the course of research is tending to ward off the evil, and make science what by divine appointment she must be, the faithful handmaid of sacred truth.

A pestilential cloud has recently passed over the country, which has marked its track every where with infidelity. It was not a natural emanation from God's works, but the same in origin with the vapors that shrouded the world in the ages of superstition, when mind was oppressed by its own imaginings. Scientific men have often been blamed for a want of interest in the phenomena. But it was mainly power drawn from nature by faithful research, that annihilated those spirits, black, white, and grizzled, of olden time; and surely there can be no less hostility to the breed now. The height of the pestilence has passed; and the best preventive of another return we can offer, is a strong infusion of inductive science.

We have reason for gratulation, that our country is beginning to appreciate the importance of scientific culture. A general movement in its favor, is in progress over the land. From the east to the far west, from the north to the south, there is a rising voice calling for this knowledge that makes nature our helpmeet in industrial pursuits, as well as our instructor in lofty truth. Universities are planned in various States: more than one has been projected in New York State alone, and in her great city, a magnificent temple consecrated to industrial science now stands nearly complete. Endowments are made to this and that institution, to meet the urgent want. Six years since, the half century closed, and a large part of the semi-centennial sermons then preached, were mainly on the triumphs of science in the fifty years just passed; and although not so recognized, it was in fact a scientific jubilee. It was followed soon by the Crystal Palace exhibition at London, and then

another in New York, and others since in Europe,—all tending to arouse the attention of the world to the true basis of national greatness, the harmonious blending, under the highest intellectual culture, of Art, Science, and Religion;—Science bestowing her profusion of gifts on genial and pliant Art, and at the same time offering her first fruits to Religion; while Religion is pointing both Science and Art upward to the source of all knowledge, and guiding them in the way of truth and righteousness.

But while the necessity of instruction in nature-truth is appreciated throughout the land, it is not clear to all, what is the best mode of supplying the need, or, in other words, what kind of schools of science and art, the country demands.

It is plain that they must be of various grades. There may be the trade school for the child, especially such children as are objects of charity. There should be other schools for youth frequenting our institutes, and for journeymen in all the various trades of the country; and then still higher schools, where teachers shall be taught, which shall be head fountains of knowledge supplying the land with its engineers, its architects, its agriculturists, its thoroughly grounded mechanics, as well as its chemists and proficients in theoretical science.

In most of the schemes for these higher institutions which are brought forward, there are two prominent errors demanding brief consideration.

First, what is thought to be needed is the practical mainly. None of your theories, they say, but the practical, unaware that the practical rests upon the true scientific as its basis, and that the two must go hand in hand, as they are one in their aim, and parts of the same system of truth.

But, *secondly*, where science seems to be appreciated, there is a tendency to be content with a meager allowance; or, with careful regard to economy to get out of one man the duty of half a dozen.

In a small village, wares of all sorts, and only a little of each, are necessarily gathered into a single shop. In striking contrast with this appear the multiplication of warehouses and profusion of each kind of product found in a large city. America has always been to Europe, as regards its means of scientific instruction, like the country to the city. But are we always to remain a country village along side of Europe? With twenty-eight millions of population may we not yet have city privileges?

Even little Saxony, with a population less than two millions—

about the size of Connecticut, Massachusetts, and Rhode Island,—has a Mining School with thirteen professors, delivering lectures on Physics, Chemistry, Mineralogy, Geology, Descriptive and Practical Geometry, Mining Machinery, Metallurgy, the Blowpipe, Assaying, Mining Jurisprudence, Drawing, and the French Language, while the greatest number of Professors that in the American mind was ever dreamed to be necessary in such an institution is two: a professor of mining, who should also be a geologist and a mineralogist, and a metallurgical professor. Indeed these two distinct branches many would think might be in the hands of one, although no mining company would trust its furnaces to the mining engineer, or the sinking of shafts to the reducer of ores.

But Saxony, although so limited in teritory, has, besides this mining school, a University of one hundred and nine professors and instructors; also five schools of arts and design, with thirty instructors; and seventeen trade schools of the first grade, with ninety-three, in the country towns, of lower grades.

Saxony is a fair example of most European states. There is no counting of dollars as to the exact cost of educating boys per head, as if raising cattle, but a wise determination to have the best of educational institutions at any expense.

Russia, thought of by many as a land of semi-barbarism, has at St. Petersburg a school of mines with forty-three professors, which is furnished with splendid cabinets of minerals, ores, and models; and among the models, there are great subterranean rooms, showing the whole inner structure of mines, into which you may descend and examine the underground works.

There is also a school of forestry, having in view the culture of trees, which has its immense gardens or forests of both indigenous trees and species brought in from various parts of the world, besides cabinets of all kinds of woods; and it controls a corps of emissaries, which it dispatches over the land for the care of the trees of the empire.

In addition to these, there are seventy-five subordinate mining establishments with two hundred and forty teachers and near seven thousand scholars; also, an extensive central school of agriculture, with various subordinate establishments; also another central school of industrial mechanics, and chemistry; another of engineering; and so on.

There are certainly some things in which we are *not* ahead of the rest of the world. And shall we not look abroad and learn wisdom? It is well known that to meet the demands of the age,

and secure success, broad plans and large capital are required. So in educational institutions, like those of which we speak, two or three associated professors may do something: but a small school will only creep along, and may be crushed by ambitious rivals. We shall find, however, a different result, if the school expand to an efficient size:—if it become a place, where the agriculturist can obtain a complete agricultural education, from chemistry, geology and the nature of soils, to the practice of farming and the raising of animals; where the mechanic may learn all that pertains to the metals and other material in machinery, all the applications of chemistry he requires, the laws of motion, the methods of applying power, and whatever is novel or instructive in the most recent patents; where those following the chemical arts, shall be equally well supplied with a good foundation, and principles as exemplified in different branches of manufacture; where the architect and engineer shall find instruction on building material and cements, in the mathematics of arches, bridges and structures generally, in physics, the use of instruments, practical engineering and drawing, in the principles of taste and the history of works of this and past times; where, too, those who would pursue science for its own sake shall be aided in acquiring all that science can teach, that they may go yet deeper in research, and bring to light other facts and principles to increase the wisdom and strength of toiling man.

The theoretical and practical should go together and on a scale of magnitude sufficient to produce results of value. Let each one whose pursuits bear on the arts or sciences compute what his special department requires, and then let all the results be combined, the decision will assuredly be that we need for efficiency a great institution, something corresponding to the country in its extent and enterprise.

Why is it that France, without mines and with few resources, is yet one of the wealthiest nations of the world, and in advance of others in the quality of many of her manufactures. France knows that there is inexhaustible wealth in nature's laws, and encourages science among all grades in society. She has her many schools of science in which the practical and theoretical are conjoined, and all under thorough organization.

At Paris there is the great Central School (L'Ecole Centrale,) the Conservatory of Arts and Trades, the School of Engineering, the School of Mines, the Polytechnic School, besides the famous Garden of Plants, an institution with vast museums and

numerous instructors in all branches of science. Subordinate to these, there are schools for special departments distributed over the empire, meeting the wants of every particular manufacture in all its details.

The French government directs special attention to the art of design and improvement of artistic skill and taste among the people, having the wit to see that taste expended on iron or copper may multiply many fold its prime value, while mere labor adds but a small percentage. The nation encourages especially chemical investigation, and reaps one of its rewards in having dyes that claim universal admiration, throwing into bad repute our Merrimack imitations; and having colors for porcelain, that also reproach us. These are two out of many examples that might be mentioned.

Prizes also are annually offered for new discoveries or investigations, and every incentive thrown out to scientific activity. From this encouragement of the arts and sciences proceeds very much of the strength and wealth of the French nation.

England saw the contrast to her disadvantage at the Crystal Palace exhibition in London, and has since organized the Department of Science and Art among the departments of the government, designed to carry out a system of scientific and polytechnic instruction over the land; and to this end £80,000 ($400,000) were appropriated for the last year.

A moment's consideration will help us to comprehend the working of such a system of education. It is to be observed that the plan we contemplate, would include mathematics to its highest departments and through its various applications; the different branches of physics and chemistry; geology in its grandeur as a record of the past, and also its developments respecting mines, building materials and soils; astronomy; mineralogy, zoölogy, botany; the logic and philosophy of the inductive sciences; modern languages, and their connection and origin; geography in its relations to climate, history, commerce and the progress of nations; drawing and the history and criticism of art; all these, besides the practical arts and sciences in their diversity.

In the first place, then, the institution in view would open a wide range of university education to those who have not the requisite Latin and Greek to pursue the ordinary college course. The plan so blends the departments of knowledge taught, that the student, if he remains long enough to take the benefits offered, will come forth,

not shaped only for a single narrow channel of life, but with cultivated intellect and broad views of the world.

In the second place, it would make proficients in special departments fitted for stations of responsibility, men, who have acquired that wide range of principles and familiarity with their operations, which will render science a tool in the hand for farther progress. You now rarely find one among our common mechanics who knows the various qualities of the metals he is working with, or the laws of motion connected with machinery, or what is new or old, exploded or accepted, among inventions. And *one* consequence is, that the man, although of much general intelligence, is confined to his single thread, year after year: *another*, that his talents, if he have ingenuity, will often be wasted on worthless inventions, or efforts to work out what was long since known, or perhaps in laborious pursuit after that mechanical *ignis fatuus*, perpetual motion. Instead of starting with existing knowledge to work successfully to a higher level, he is groping in the darkness that was long since dispelled from the walks of true science and art.

There has recently been a "perpetual motion" machine in this region. The inventor knew the deception he was practising. But a large part of the mechanics that saw it were more than half satisfied that the great problem had been here solved, and incredulous science proved at fault. But should the secret be divulged, they would be surprised to find how they were deceived. All the arts afford similar illustrations of wasted means and misspent powers.

Again, such an institution would furnish men able to teach and spread sound knowledge around them, and so raise the standard of art education, besides protecting multitudes from follies and foolish expenditure.

Again, it would call into play the latent talent of thousands that now tread only in beaten paths, and open numberless channels of labor almost unoccupied. It would cultivate general taste, which is becoming more and more important in all our manufactures. It would tend to render the laws of nature universal in their benefits, by placing them at the command of the many over the land. With such results, the institution would assuredly become a chief source of national wealth and prosperity.

It is a striking fact, illustrating our poverty as an industrial people, that Mr. Goodyear, now in Paris, could not find the taste or artists here, able to design or make the articles which he required in the development of the india rubber manufacture.

There is, too, the still wider fact, that very many of the arts are pursued in this country only through artists imported from Europe.

We *should* have our own centers of strength and vitality; and this we aim to secure. With a plan of education of the kind explained fully carried out, the country may hope to take a stand on terms of equality with other civilized nations.

Here is a system of internal improvements that looks deeper than to the welfare of harbors and rivers. It strikes at the working mind of the nation. It takes its station above the common and high schools, to receive the youths there prepared with the elements of knowledge, and fit them for positions of honor and usefulness in the sciences, commerce, manufactures, agriculture, and other walks of life.

The results looked for, will not be the outflow of the University in itself alone. For such University schools produce, as a natural consequence, subordinate schools. The lower trade schools, where the details of each trade shall be taught, will multiply over the land in every town or county, as part of the fruits of the system. The university must first exist to afford the teachers for such schools. Once in full action, a flow of benefits will proceed from it that will cover the continent.

I have said that the age was calling for schools of science, and that many attempts are making through the land to meet the call.

The question with us is, shall this be the great seat of learning for the country? Shall the institution which took root with almost the first germs of civilization on the continent, and which has spread its branches widely, so as to be second to none in its compass and influence, still continue to expand with the expanding mind of the world? Or, shall we be content with the past, and see others imbibing the spirit of the age, and through the new vigor derived, rise beyond us, till like other shaded plants, Yale shall begin to dwindle, her laurels fade?

Ten years since, the Department of Philosophy and the Arts was projected (and the following year instituted,) by the Corporation of Yale College, to cover special instruction in general and practical science and the higher branches of literature. At that time, in 1846, the Yale School of Science, embracing chemistry applied to agriculture and the arts, was commenced, under Professor Benjamin Silliman, Jr., and Professor John Pitkin Norton, the latter, to our grief and great loss, since deceased. They worked

zealously, and for naught but the satisfaction of promoting the spread of scientific knowledge; for the income of the year never exceeded its expenditures. This school has continued its existence, and in it, many of the best young chemists of the land have taken their first steps in science. A professor of engineering has since been added; and already over 300 pupils have been here under instruction. As the school now stands, it has a professor of chemistry applied to the arts, a professor of agricultural chemistry, one of metallurgy, one of engineering, and through its connection with Yale College, one of geology, mineralogy, and general zoölogy; in other words, as is seen, one professor corresponds to a whole school of professors abroad. Moreover the school is without endowment. Still, there is here an organization, embracing nearly all that is required in theoretical science, with a part of the practical; and though incomplete, it has had a good measure of success.

The present organization only needs expansion, and adaptation to broader purposes; that is, a full corps of professors, so that the several sciences and arts shall all be subjects profoundly, and not one-sidedly taught; and it is important that there should be included that thorough instruction in the philosophy of geography, history, language, taste, and inductive reasoning, which will make the graduate an educated man, and an honor to the university. Several gentlemen of the College faculty, and others on the ground, are ready to coöperate toward this great end.

As the different departments contemplated in the plan are all embraced in one school, each does not require an independent corps of teachers; for a professor may instruct in half a dozen different sections, without much increased labor. A full organization, therefore, could be accomplished with only a moderate number of men, not much exceeding the corps of a school for a single department abroad.

The execution of the proposed plan, requires also a building, containing laboratories, lecture-rooms, and a museum of specimens and models; it needs, too, a farm for the agricultural department.

The museum, moreover, should be a spacious one, containing collections connected with all the subjects taught in the school: specimens in natural history; seeds, soils, implements and plans for the section of agriculture; models of bridges, arches, buildings, roads, aqueducts, samples of materials for construction, and a cabinet of physical apparatus, for the sections of engineering and architecture; collections of machines, models of new inventions, involving important principles, and collections of materials and im-

plements for the section of industrial mechanics, collections of art-products in all their stages of perfection, and their many varieties; collections of ores, and metallurgical products, models of mines and furnaces for the department of mining and metallurgy. In fact, the museum should lecture to the eye, and thoroughly in all the sections represented, so that no one could walk through the halls without profit. It should be a place where the public passing in and out, should gather something of the spirit, and much of the knowledge, of the institution.

Already, through the liberality of one of the citizens of New Haven, a fine lot has been set apart conditionally for the school,—one more beautiful or more convenient could not be found in or about the city. The condition is simply that of occupation and our having the means of success. No city in the land is a more favorable place for such an institution. The presence of the College, her large libraries and mineral collections, her professors and means of instruction, give it a vast advantage, being a portion of the capital of the school greater than we can estimate.

There is another need, which has not been alluded to, as it requires its own liberal foundation. I refer to an astronomical observatory. Yale, to this time, has none. The temporary arrangement on College grounds, where the Clarke telescope stands, merits many honorable words for directing early attention to this subject, and for its able contributions to astronomical science. But it is not an observatory, and has not been so regarded; and one fine instrument, the gift to the College of William Hillhouse, Esq., of this city, is stored away for want of a place to mount it, while an astronomical clock, from the same generous donor, is wasting time in the Library. May Yale, which had an early start in this department, be unsurpassed in her equipments, whenever the time for action comes. The regions of space to their farthest penetrable limits, will then be within her range of vision and study.

The department of philosophy and the arts, here instituted to embrace these various subjects, stands on the same independent basis with that of theology, law or medicine. While each is alike independent of the College proper, or academic department, one mantle covers all, and the same seal and the same honored name are affixed to all the diplomas.

My remarks thus far have had special reference to scientific courses of study, since these are less generally understood, and are more neglected among us, than those of any other branch of education. But the plan does not stop here: only a little wider expan-

sion of the scheme,—such as is contemplated, in fact,—and it will cover the highest branches of literary as well as scientific education, adapted to carry forward the graduate of the College, through a full university system of classical or other studies. Let there be a one or two years course of lectures and instruction arranged, which shall include general history, philology, ethnology, belles lettres, the history of philosophy, and other intellectual studies, and the number of resident graduates would greatly increase, and a new era dawn upon American learning. Not till this is accomplished, will the department of philosophy and the arts projected, become a realized fact. Not till then, can we hope to prevent our youth from seeking in the atmosphere of Germany the knowledge for which they yearn. The tide in that direction is on the constant increase. In one year, out of a dozen students in the Yale scientific school, half of them left for Europe; and the walks of literature illustrate the same fact. It is surely time for earnest and determined action.

GENTLEMEN OF THE ALUMNI:—

The plan is before you. It bears its own evidence that in the will of her men and the breadth of her aims, Yale is determined to be up to the times. The desire is manifest that the College, as it now stands, shall not longer mark the limit of American training in literature or science, but that higher paths be laid out, and broader fields surveyed and occupied.

Notwithstanding the clouds about our political horizon, we believe that America, free America, is to be the hope of the world; that she will yet take the lead among the nations, in population, wealth, education, benevolence, and all that adorns humanity. And in this growing nation, we see our revered Alma Mater, great also,—unexcelled; in the number of her students, beyond every other; in active interest in the welfare of her youths—but we would not boast. The first university in the leading nation of the globe,—dare we hope it? Why not let it so be? Why not have here, in this land of genial influences, beneath these noble elms, that seem like a realization of the classic shades of Greece,—but where a higher philosophy than that of Socrates, the philosophy that centers in Christ our chiefest glory, is the pervading spirit,—why not have here, THE AMERICAN UNIVERSITY,—where nature's laws shall be taught in all their fullness, and intellectual culture reach its highest limit! The affluence of nature should be our model: and if so, the greater the glory to this seat of learning, and the vaster the blessing to our country and the world.

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